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(54) Monitoring the internal impedance of an accumulator battery in an uninterruptible power supply.

(57) In an uninterruptible power supply, during the discharge of a battery 1 to a load 3, the current induced by the load and passing through the battery is measured e or calculated c, and the corresponding AC ripple voltage component produced on the battery voltage is measured a, the value for the internal impedance of the battery being calculated from these values in a computer 9. The obtained impedance value is compared to a predetermined reference value to determine the condition of the battery, and an alarm and/or shutdown signal d is produced if the reference value is exceeded. The system also includes an inverter 10 and battery charger 7.

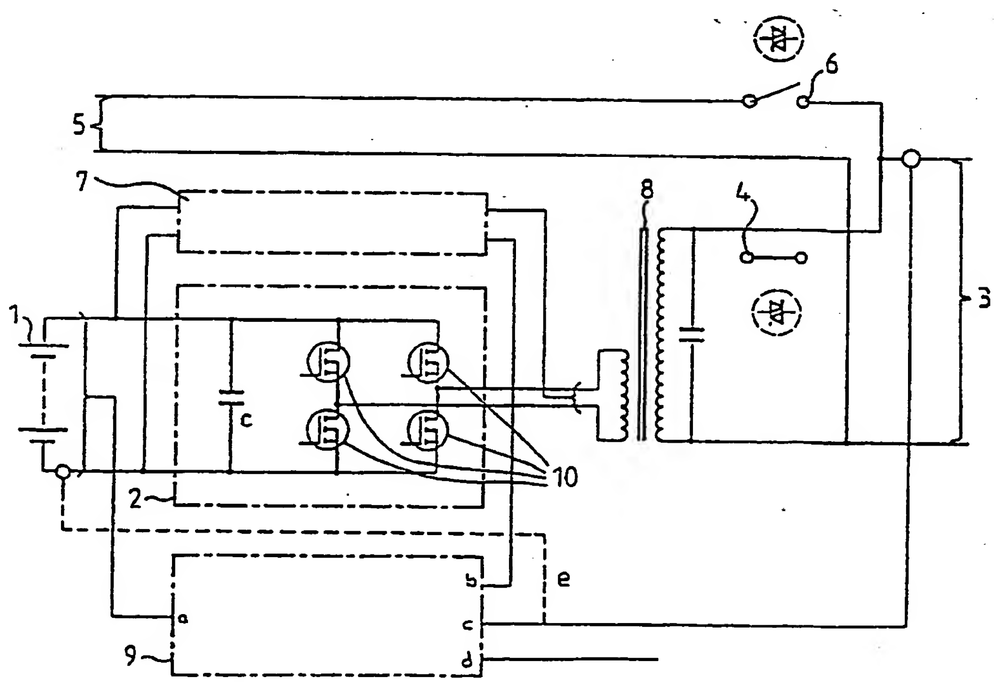

FIG. 2

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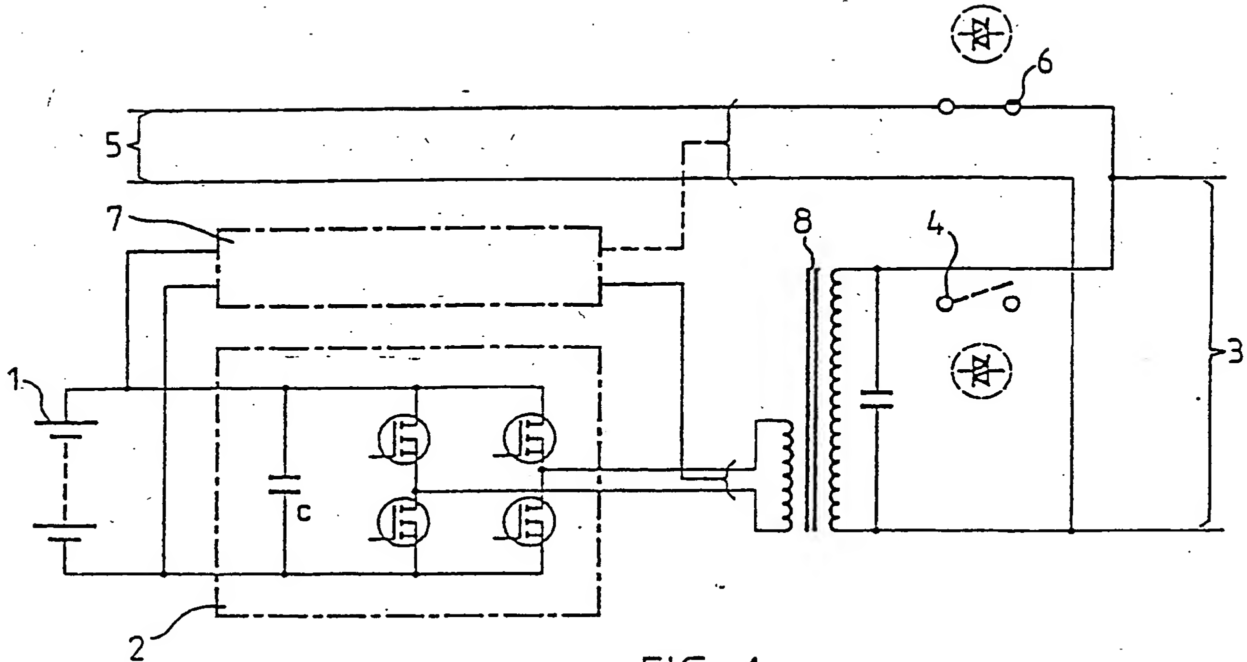

FIG. 1

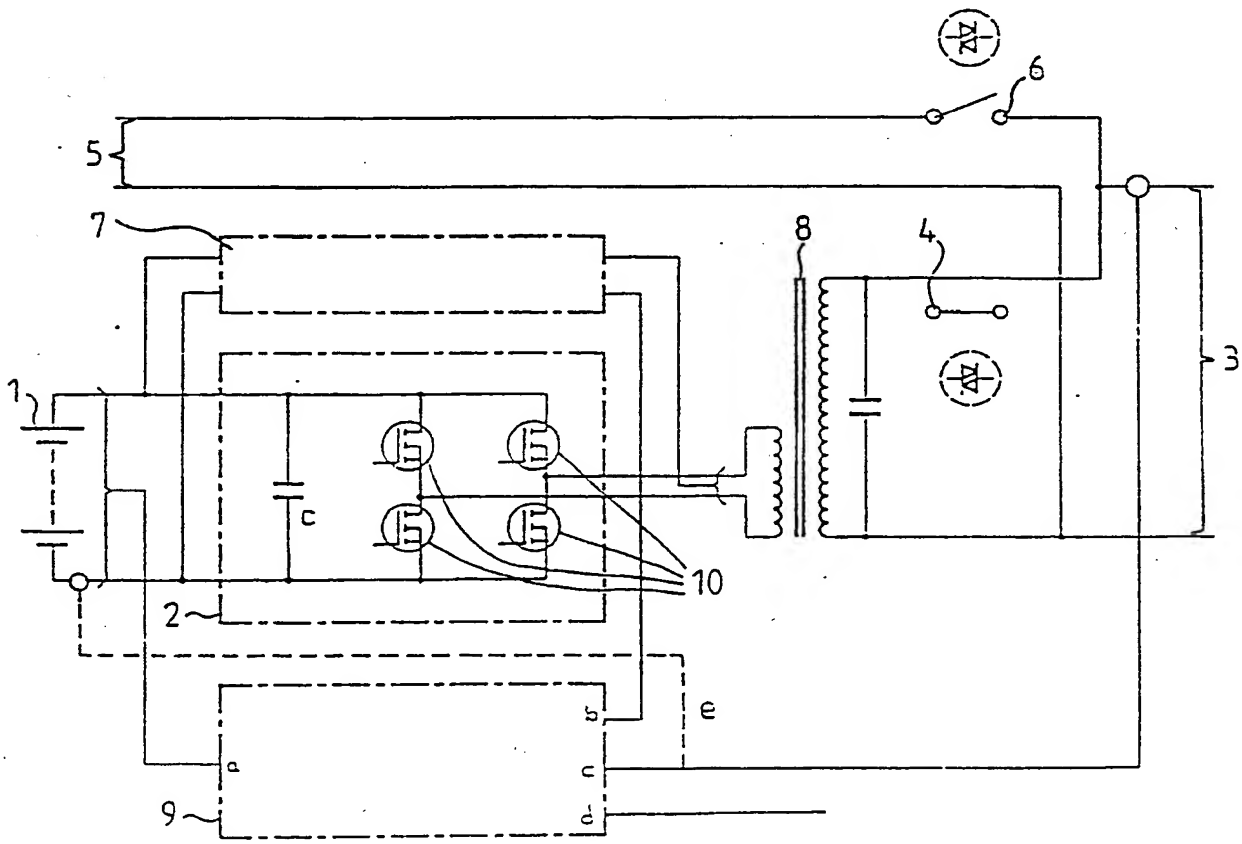

FIG. 2

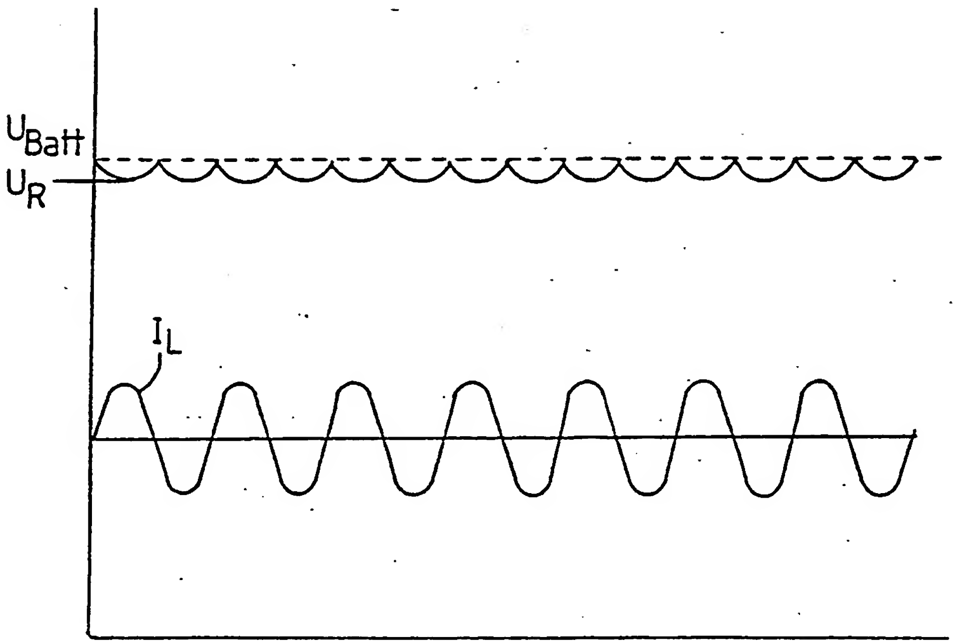

FIG. 3

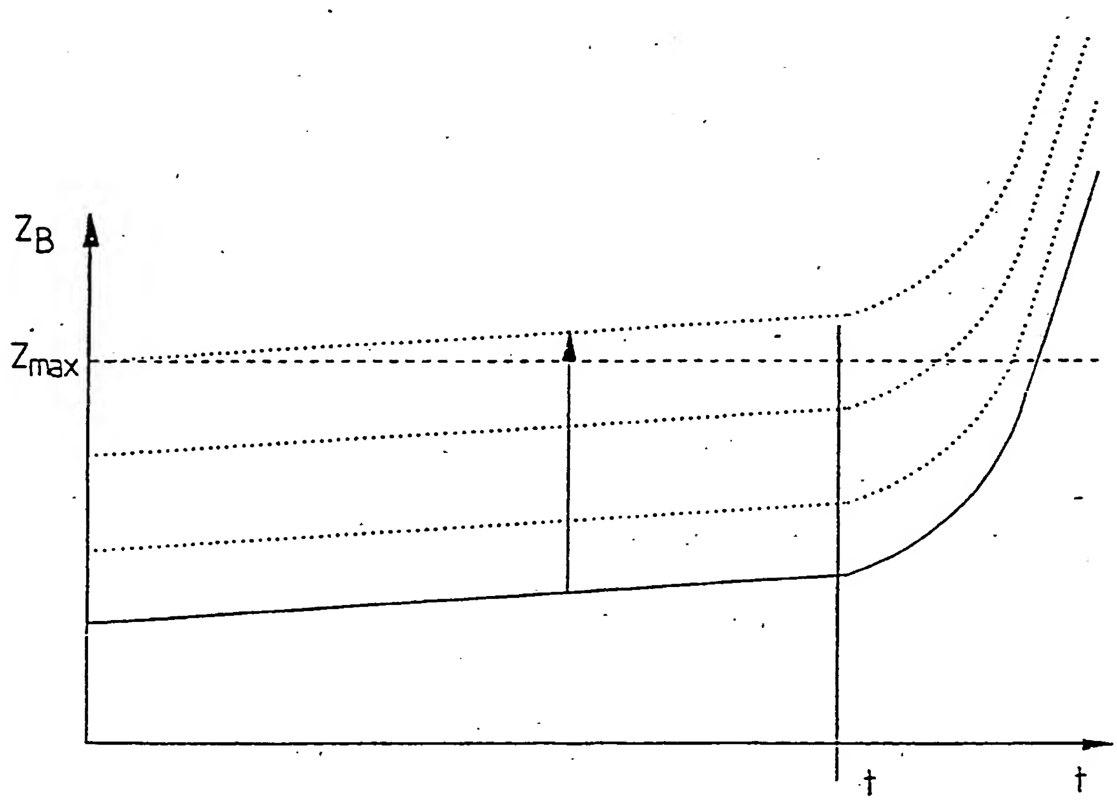

FIG. 4

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A method of monitoring the internal impedance of an accumulator battery in an uninterruptible power supply, and a UPS

The present invention relates to a method of monitoring the internal impedance of an accumulator battery in an uninterruptible power supply, and a UPS.

In uninterruptible power supplies (UPS) for computers and other apparatus that are sensitive to power interruptions and the like, the reserve energy source in general consists of a series of lead acid cells that, in a case of power interruption, can be rapidly connected electronically via an inverter and thereby AC current can be supplied to the system connected to the UPS. The purpose of the UPS is partly to bridge shorter power interruptions, partly to signal the data system in cases of mains interruptions of longer duration, so the computer can be shut down automatically in a controlled manner without damage, e.g. in lost files, before the limited energy stored in the battery is completely exhausted.

In certain known UPSs, the condition and charging of the battery is hardly supervised at all, but is controlled by means of continuous charging voltage (float charge) that must be sufficiently high to charge all cells in the battery but not so high as to overcharge any of the cells. Undercharging of the battery may result in sulphatation ($PbSO_4$) of the electrode plates in the cells. Such sulphate build-up is a normal and reversible discharge process in a lead acid battery, but in a continuous undercharge condition also non-recoverable sulphate crystals degrading the capacity of the battery are created. Overcharging in turn may result in drying out of the electrolyte of the battery and cause elevated corrosion of the electrode grids and associated conductors. Overcharging

may further cause bridging phenomena finally resulting in short circuiting between the electrodes. Also overheating of individual battery cells may occur, particularly with several series connected battery cells, as variations in the individual voltages of the cells may appear.

Other known solutions utilize individual cell-voltage measurements, but the associated hardware and installations are expensive. Further, it is a known fact that potential battery failures are best detected during discharge, particularly near the point when the nominal capacity of the battery is nearly totally exhausted, i.e. where variations in the charged capacity really show. There are also applications in which deliberate discharge of the battery is performed for a certain period of time, but the discharge that is required to achieve a reliable estimate of the battery capacity must be weighed against the risk of power interruptions when the battery is at its most discharged state. In critical applications, this risk is not acceptable.

It is also known that the internal impedance of a battery, expressed for instance as the value of an AC voltage applied over the battery divided by the AC current obtained in the battery, is an indicator of the general condition of the battery. The internal impedance of a battery increases with increasing sulphatation of the electrodes, corrosion of conductors etc., and increased drying out of electrolyte in the battery. The internal impedance of the battery therefore constitutes an important indicator of the performance of the battery. However, there is no known system available that would measure this impedance in a simple manner.

It is an object of the present invention to pro-

vide a method and an apparatus for measuring the internal impedance of an accumulator battery in a UPS in a simple and reliable way. To achieve this, the method of the invention is characterized in that during the discharge of the battery to the load, the current induced by the load, passing through the battery, is measured or calculated, and the corresponding AC voltage component obtained on the battery voltage is measured, the value for the internal impedance of the battery being calculated from these values, and that the obtained impedance value is compared to a predetermined reference value to determine the condition of the battery.

Preferred embodiments of the method and UPS of the invention are set forth in the ensuing claims. In the following, the invention will be explained in more detail with reference to the accompanying drawings, in which

Figure 1 shows a conventional UPS,

Figure 2 shows a UPS according to the invention,

Figure 3 shows typical current and voltage curves essential to the method of the invention with reference to Figure 2,

Figure 4 is a graphical representation of a typical graph for the internal impedance of the battery.

Figure 1 shows a conventional UPS wherein the battery 1 and the associated inverter 2 are normally disconnected from the output 3 of the UPS by means of a switch 4. The load is in this operational mode supplied directly from the mains supply 5. At a mains interruption, the mains supply is disconnected by switch 6, the inverter 2 is activated and connected to the load through switch 4. After mains voltage recovery, the initial state is resumed, whilst the charger

7 recharges the battery 1. The purpose of the transformer 8 is primarily to transform the output voltage of the inverter into a suitable load voltage during mains interruption. It can also provide energy from the load voltage to the charger 7 under normal conditions, if there is no switch 4. The switch 4 can be replaced by the switching functions of the semiconductor switches 10 of the main circuit of the inverter. A modern UPS usually also includes a logic unit performing various control functions of the different components of the UPS and also provides the necessary warning signals to users of the connected system.

Figure 2 shows a UPS according to the invention, comprising as shown in Figure 1 a battery 1, an inverter 2, switches 4, 6, a charger 7 and a transformer 8. The UPS further comprises a logic unit, such as a microcomputer 9, for performing the necessary control functions which will be described hereinafter. As in the apparatus of Figure 1, the battery 1 and inverter 2 are disconnected during normal line operation, no load current passing through them, but the UPS is now shown as connected to the load. The battery voltage is monitored by the computer unit 9 and is read at the input a. The computer unit can initiate charging of the battery by means of a signal from an output b to the charger 7.

Measuring of the internal impedance of the battery is effected as follows: When a line failure occurs, the load current I_L is monitored by the computer unit 9 via input c. The measured value can be used as an approximation of the battery current when multiplied with the turn ratio N of the transformer 8. The internal impedance can be calculated on the basis of the AC component, ripple U_R, generated by the load

current on the battery voltage U_{Batt} when the battery is connected to the load, see Figure 3 showing a typical curve for the battery voltage U_{Batt} at a sinusoidal load current I_L. The frequency of this component is twice the mains frequency. By allowing the computer unit to measure, at input a, this AC component and dividing it by the load current for the corresponding period of time, the value $Z_B=U_R/(I_L*N)$ of the internal impedance of the battery is obtained. The measurement of the load current and the AC component may be based on instantaneous values, average values, RMS values, etc. Different algorithms for different measuring methods can easily be programmed into the computer unit 9 to meet different requirements.

When the value of the internal impedance exceeds a predetermined limit, the computer unit may issue an alarm of imminent battery exchange to the connected system via a connection d, and/or initiate shutdown of the connected system.

Alternatively, the battery current can be measured directly (broken line e) in the battery instead of calculating it via the load current. It is an essential feature of the invention that the battery current and thereby its internal impedance can be calculated under discharge in a simple and reliable way not impairing the charge of the battery under normal conditions. Naturally, the battery can be tested employing the method of the invention for instance during servicing in such a way that the serviceman connects a load on the UPS and disconnects the mains voltage, simultaneously reading the impedance values of the battery.

Figure 4 is a graphical representation of a typical curve for the internal impedance Z_B of the battery on a time axis. The impedance increases during

discharge on account of the chemical processes taking place in the battery. The initial level of the impedance is the critical quantity, and a suitable threshold Z_{max} must be selected. When the initial level exceeds the threshold on account of irreversible sulphatation processes, corrosion etc., this increases the risk for inadequate battery capacity, thereby risking the nominal backup time t_1 of the UPS, causing shut-off of the connected system.

It is understood by one skilled in the art that the invention is not restricted to the examples given above, but its different embodiments may vary within the scope of the ensuing claims.

Claims:

1. Method of monitoring the internal impedance of an accumulator battery (1) in an uninterruptible power supply, c h a r a c t e r i z e d in that during the discharge of the battery to the load, the load current (I_L) induced by the load and passing through the battery (1) is measured or calculated, and the corresponding AC voltage component (U_R) obtained on the battery voltage (U_{Batt}) is measured, the value for the internal impedance (Z_B) of the battery being calculated from these values, and that the obtained impedance value is compared to a predetermined reference value (Z_{max}) to determine the condition of the battery.

2. A method as claimed in claim 1, c h a r a c t e r i z e d in that when the measured impedance value (Z_B) is found to exceed the predetermined reference value (Z_{max}), an alarm signal is issued to the connected system.

3. A method as claimed in claim 1 or 2, c h a r a c t e r i z e d in that when the measured impedance value (Z_B) is found to exceed the predetermined reference value (Z_{max}), shutdown of the connected system is initiated.

4. A method as claimed in claim 1, 2 or 3, c h a r a c t e r i z e d in that the current passing through the battery (1) is calculated during discharge of said battery to the load by measuring the load current (I_L).

5. An uninterruptible power supply, comprising a battery (1), an inverter (2) for inverting the battery voltage, switches (4, 6) for altering the power supply connected to the load, a charger (7) for charging the battery, and a logic unit (9) for performing various

control functions, c h a r a c t e r i z e d in that the logic unit (9) for monitoring the internal impedance of the battery is adapted to measure or calculate the load current (I_L) caused by the load and passing through the battery during the discharge of the battery (1) to the load, and to measure the corresponding AC component (U_R) on the battery voltage (U_{Batt}), and to compare a calculated value for the internal impedance (Z_B) to a predetermined reference value (Z_{max}) and to determine the condition of the battery on the basis of the comparison.

6. An uninterruptible power supply as claimed in claim 5, c h a r a c t e r i z e d in that when the measured impedance value (Z_B) is found to exceed the predetermined reference value (Z_{max}) the logic unit (9) is adapted to issue a signal thereon to the connected system.

7. An uninterruptible power supply as claimed in claim 5 or 6, c h a r a c t e r i z e d in that the logic unit (9) is adapted to calculate the current passing through the battery (1) by means of the load current (I_L).

8. A method of monitoring the internal impedance of an accumulator battery substantially as hereinbefore described with reference to Figures 2 to 4 of the accompanying drawings.

9. An uninterruptible power supply substantially as hereinbefore described with reference to the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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Relevant Technical Fields

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(ii) Int Cl (Ed.5) G01R (31/36); H02H (7/18)

Search Examiner
D C BRUNT

Date of completion of Search
23 NOVEMBER 93

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES: WPI

Documents considered relevant following a search in respect of Claims :-
1-9

Categories of documents

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Category	Identity of document and relevant passages	Relevant to claim(s)
A	US 4697134 (BURKUM)	

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